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Recommended Practice: Guide to the Use of the ATSC Digital Television Standard

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The Advanced Television Systems Committee, Inc., is an international, non-profit organization developing voluntary standards for digital television. The ATSC member organizations represent the broadcast, broadcast equipment, motion picture, consumer electronics, computer, cable, satellite, and semiconductor industries. Specifically, ATSC is working to coordinate television standards among different communications media focusing on digital television, interactive systems, and broadband multimedia communications. ATSC is also developing digital television implementation strategies and presenting educational seminars on the ATSC standards.

ATSC was formed in 1982 by the member organizations of the Joint Committee on InterSociety Coordination (JCIC): the Electronic Industries Association (EIA), the Institute of Electrical and Electronic Engineers (IEEE), the National Association of Broadcasters (NAB), the National Cable and Telecommunications Association (NCTA), and the Society of Motion Picture and Television Engineers (SMPTE). Currently, there are approximately 160 members representing the broadcast, broadcast equipment, motion picture, consumer electronics, computer, cable, satellite, and semiconductor industries.

ATSC Digital TV Standards include digital high definition television (HDTV), standard definition television (SDTV), data broadcasting, multichannel surround-sound audio, and satellite direct-to-home broadcasting.

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1. SCOPE

This guide provides tutorial information and an overview of the digital television system defined by ATSC Standard A/53, *ATSC Digital Television Standard.* In addition, recommendations are given for operating parameters for certain aspects of the DTV system.

2. REFERENCES

2.1 Normative References

There are no normative references.

2.2 Informative References

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26. SMPTE Recommended Practice 202 (2002): "Video Alignment for MPEG Coding," Society of Motion Picture and Television Engineers, White Plains, N.Y., 2002.
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3. DEFINITIONS

The following definitions are included here for reference but the precise meaning of each may vary slightly from standard to standard. Where an abbreviation is not covered by IEEE practice, or industry practice differs from IEEE practice, then the abbreviation in question will be described in Section 3.3 of this document. Many of the definitions included therein are derived from definitions adopted by MPEG.

3.1 Treatment of Syntactic Elements

This document contains symbolic references to syntactic elements used in the audio, video, and transport coding subsystems. These references are typographically distinguished by the use of a different font (e.g., restricted), may contain the underscore character (e.g., sequence_end_code) and may consist of character strings that are not English words (e.g., dynrng).

3.2 Terms Employed

For the purposes of the Digital Television Standard, the following definitions apply:

ACATS Advisory Committee on Advanced Television Service.

access unit A coded representation of a presentation unit. In the case of audio, an access unit is the coded representation of an audio frame. In the case of video, an access unit includes all the coded data for a picture, and any stuffing that follows it, up to but not including the start of the next access unit. If a picture is not preceded by a group_start_code or a

sequence_header_code, the access unit begins with a picture start code. If a picture is preceded by a group_start_code and/or a sequence_header_code, the access unit begins with the first byte of the first of these start codes. If it is the last picture preceding a sequence_end_code in the bit stream, all bytes between the last byte of the coded picture and the sequence_end_code (including the sequence_end_code) belong to the access unit.

A/D Analog to digital converter.

AFT Active format description.

AES Audio Engineering Society.

anchor frame A video frame that is used for prediction. I-frames and P-frames are generally used as anchor frames, but B-frames are never anchor frames.

ANSI American National Standards Institute.

asynchronous transfer mode (ATM) A digital signal protocol for efficient transport of both constant-rate and bursty information in broadband digital networks. The ATM digital stream consists of fixed-length packets called "cells," each containing 53 8-bit bytes—a 5-byte header and a 48-byte information payload.

ATM See *asynchronous transfer mode.*

ATTC Advanced Technology Test Center.

AWGN Additive white Gaussian noise.

bidirectional pictures or **B-pictures** or **B-frames** Pictures that use both future and past pictures as a reference. This technique is termed *bidirectional prediction*. B-pictures provide the most compression. B-pictures do not propagate coding errors as they are never used as a reference.

bit rate The rate at which the compressed bit stream is delivered from the channel to the input of a decoder.

block A block is an 8-by-8 array of pel values or DCT coefficients representing luminance or chrominance information.

bps Bits per second.

byte-aligned A bit in a coded bit stream is byte-aligned if its position is a multiple of 8-bits from the first bit in the stream.

channel A digital medium that transports a digital television stream.

coded representation A data element as represented in its encoded form.

compression Reduction in the number of bits used to represent an item of data.

constant bit rate Operation where the bit rate is constant from start to finish of the compressed bit stream.

conventional definition television (CDTV) This term is used to signify the *analog* NTSC television system as defined in ITU-R Recommendation 470. See also *standard definition television* and ITU-R Recommendation 1125.

CRC The cyclic redundancy check used to verify the correctness of the data.

D-frame A frame coded according to an MPEG-1 mode that uses dc coefficients only.

data element An item of data as represented before encoding and after decoding.

DCT See *discrete cosine transform.*

decoded stream The decoded reconstruction of a compressed bit stream.

decoder An embodiment of a decoding process.

decoding (process) The process defined in the Digital Television Standard that reads an input coded bit stream and outputs decoded pictures or audio samples.

decoding time-stamp (DTS) A field that may be present in a PES packet header which indicates the time that an access unit is decoded in the system target decoder.

DFS Data field synchronization.

digital storage media (DSM) A digital storage or transmission device or system.

discrete cosine transform A mathematical transform that can be perfectly undone and which is useful in image compression.

DSM-CC Digital storage media command and control.

DSM Digital storage media.

DSS Data segment synchronization.

DTV Digital television, the system described in the ATSC Digital Television Standard.

DTS See *decoding time-stamp*.

D/U Desired (signal) to undesired (signal) ratio.

DVCR Digital video cassette recorder

editing A process by which one or more compressed bit streams are manipulated to produce a new compressed bit stream. Conforming edited bit streams are understood to meet the requirements defined in the Digital Television Standard.

elementary stream (ES) A generic term for one of the coded video, coded audio, or other coded bit streams. One elementary stream is carried in a sequence of PES packets with one and only one stream_id.

elementary stream clock reference (ESCR) A time stamp in the PES Stream from which decoders of PES streams may derive timing.

EMM See *entitlement management message*.

encoder An embodiment of an encoding process.

encoding (process) A process that reads a stream of input pictures or audio samples and produces a valid coded bit stream as defined in the Digital Television Standard.

entitlement control message (ECM) Entitlement control messages are private conditional access information that specify control words and possibly other stream-specific, scrambling, and/or control parameters.

entitlement management message (EMM) Entitlement management messages are private conditional access information that specify the authorization level or the services of specific decoders. They may be addressed to single decoders or groups of decoders.

entropy coding Variable length lossless coding of the digital representation of a signal to reduce redundancy.

entry point Refers to a point in a coded bit stream after which a decoder can become properly initialized and commence syntactically correct decoding. The first transmitted picture after an entry point is either an I-picture or a P-picture. If the first transmitted picture is not an I-picture, the decoder may produce one or more pictures during acquisition.

ES See *elementary stream*.

essence In its simplest form, *essence* = content – metadata. In this context, (video) essence is the image itself without any of the transport padding (H and V intervals, ancillary data, etc).

event An event is defined as a collection of elementary streams with a common time base, an associated start time, and an associated end time.

field For an interlaced video signal, a "field" is the assembly of alternate lines of a frame. Therefore, an interlaced frame is composed of two fields, a top field and a bottom field.

FIR Finite-impulse-response.

forbidden This term, when used in clauses defining the coded bit stream, indicates that the value must never be used. This is usually to avoid emulation of start codes.

FPLL Frequency and phase locked loop.

frame A frame contains lines of spatial information of a video signal. For progressive video, these lines contain samples starting from one time instant and continuing through successive lines to the bottom of the frame. For interlaced video, a frame consists of two fields, a top field and a bottom field. One of these fields will commence one field later than the other.

GOP See *group of pictures.*

group of pictures (GOP) A group of pictures consists of one or more pictures in sequence.

HDTV See *high-definition television.*

high-definition television (HDTV) High-definition television provides significantly improved picture quality relative to conventional (analog NTSC) television and a wide screen format (16:9 aspect ratio). The ATSC Standard enables transmission of HDTV pictures at several frame rates and one of two picture formats; these are listed in the top two lines of Table 5.1. The ATSC Standard also enables the delivery digital sound in various formats.

high level A range of allowed picture parameters defined by the MPEG-2 video coding specification that corresponds to high-definition television.

Huffman coding A type of source coding that uses codes of different lengths to represent symbols that have unequal likelihood of occurrence.

IEC International Electrotechnical Commission.

intra coded pictures or **I-pictures** or **I-frames** Pictures that are coded using information present only in the picture itself and not depending on information from other pictures. I-pictures provide a mechanism for random access into the compressed video data. I-pictures employ transform coding of the pel blocks and provide only moderate compression.

ISI Intersymbol interference.

ISO International Organization for Standardization.

ITU International Telecommunication Union.

layer One of the levels in the data hierarchy of the video and system specification.

level A range of allowed picture parameters and combinations of picture parameters.

LMS Least mean squares.

macroblock In the DTV system a macroblock consists of four blocks of luminance and one each Cr and Cb block.

main level A range of allowed picture parameters defined by the MPEG-2 video coding specification with maximum resolution equivalent to ITU-R Recommendation 601.

main profile A subset of the syntax of the MPEG-2 video coding specification.

Mbps 1,000,000 bits per second.

motion vector A pair of numbers that represent the vertical and horizontal displacement of a region of a reference picture for prediction.

MP@HL Main profile at high level.

MP@ML Main profile at main level.

MPEG Refers to standards developed by the ISO/IEC JTC1/SC29 WG11, *Moving Picture Experts Group.* MPEG may also refer to the Group itself.

MPEG-1 Refers to ISO/IEC standards 11172-1 (Systems), 11172-2 (Video), 11172-3 (Audio), 11172-4 (Compliance Testing), and 11172-5 (Technical Report).

MPEG-2 Refers to ISO/IEC standards 13818-1 (Systems), 13818-2 (Video), 13818-3 (Audio), 13818-4 (Compliance).

pack A pack consists of a pack header followed by zero or more packets. It is a layer in the system coding syntax.

packet data Contiguous bytes of data from an elementary data stream present in the packet.

packet identifier (PID) A unique integer value used to associate elementary streams of a program in a single or multi-program transport stream.

packet A packet consists of a header followed by a number of contiguous bytes from an elementary data stream. It is a layer in the system coding syntax.

padding A method to adjust the average length of an audio frame in time to the duration of the corresponding PCM samples, by continuously adding a slot to the audio frame.

payload Payload refers to the bytes that follow the header byte in a packet. For example, the payload of a transport stream packet includes the PES_packet_header and its PES_packet_data_bytes or pointer_field and PSI sections, or private data. A PES_packet_payload, however, consists only of PES_packet_data_bytes. The transport stream packet header and adaptation fields are not payload.

PCR See *program clock reference.*

pel See *pixel.*

PES packet header The leading fields in a PES packet up to but not including the PES_packet_data_byte fields where the stream is not a padding stream. In the case of a padding stream, the PES packet header is defined as the leading fields in a PES packet up to but not including the padding_byte fields.

PES packet The data structure used to carry elementary stream data. It consists of a packet header followed by PES packet payload.

PES stream A PES stream consists of PES packets, all of whose payloads consist of data from a single elementary stream, and all of which have the same stream_id.

PES Packetized elementary stream.

picture Source, coded, or reconstructed image data. A source or reconstructed picture consists of three rectangular matrices representing the luminance and two chrominance signals.

PID See *packet identifier.*

pixel "Picture element" or "pel." A pixel is a digital sample of the color intensity values of a picture at a single point.

predicted pictures or **P-pictures** or **P-frames** Pictures that are coded with respect to the nearest *previous* I or P-picture. This technique is termed *forward prediction.* P-pictures provide more compression than I-pictures and serve as a reference for future P-pictures or B-pictures. P-pictures can propagate coding errors when P-pictures (or B-pictures) are predicted from prior P-pictures where the prediction is flawed.

presentation time-stamp (PTS) A field that may be present in a PES packet header that indicates the time that a presentation unit is presented in the system target decoder.

presentation unit (PU) A decoded audio access unit or a decoded picture.

profile A defined subset of the syntax specified in the MPEG-2 video coding specification.

program clock reference (PCR) A time stamp in the transport stream from which decoder timing is derived.

program element A generic term for one of the elementary streams or other data streams that may be included in the program.

program specific information (PSI) PSI consists of normative data that is necessary for the demultiplexing of transport streams and the successful regeneration of programs.

program A program is a collection of program elements. Program elements may be elementary streams. Program elements need not have any defined time base; those that do have a common time base and are intended for synchronized presentation.

PSI See *program specific information.*

PSIP Program and System Information Protocol, as defined in ATSC A/65.

PTS See *presentation time-stamp.*

quantizer A processing step that intentionally reduces the precision of DCT coefficients.

random access The process of beginning to read and decode the coded bit stream at an arbitrary point.

reserved This term, when used in clauses defining the coded bit stream, indicates that the value may be used in the future for Digital Television Standard extensions. Unless otherwise specified, all reserved bits are set to "1".

ROM Read-only memory.

SAW filter Surface-acoustic-wave filter.

SCR See *system clock reference.*

scrambling The alteration of the characteristics of a video, audio, or coded data stream in order to prevent unauthorized reception of the information in a clear form. This alteration is a specified process under the control of a conditional access system.

SDTV See *standard definition television.*

slice A series of consecutive macroblocks.

SMPTE Society of Motion Picture and Television Engineers.

source stream A single, non-multiplexed stream of samples before compression coding.

splicing The concatenation performed on the system level of two different elementary streams. It is understood that the resulting stream must conform totally to the Digital Television Standard.

standard definition television (SDTV) This term is used to signify a *digital* television system in which the quality is approximately equivalent to that of NTSC. This equivalent quality may be achieved from pictures sourced at the 4:2:2 level of ITU-R Recommendation 601 and subjected to processing as part of bit rate compression. The results should be such that when judged across a representative sample of program material, subjective equivalence with NTSC is achieved. See also *conventional definition television* and ITU-R Recommendation 1125.

start codes 32-bit codes embedded in the coded bit stream that are unique. They are used for several purposes including identifying some of the layers in the coding syntax. Start codes consist of a 24 bit prefix (0x000001) and an 8 bit stream_id.

STC System time clock.

STD See *system target decoder.*

STD input buffer A first-in, first-out buffer at the input of a system target decoder for storage of compressed data from elementary streams before decoding.

still picture A coded still picture consists of a video sequence containing exactly one coded picture that is intra-coded. This picture has an associated PTS and the presentation time of succeeding pictures, if any, is later than that of the still picture by at least two picture periods.

system clock reference (SCR) A time stamp in the program stream from which decoder timing is derived.

system header The system header is a data structure that carries information summarizing the system characteristics of the Digital Television Standard multiplexed bit stream.

system target decoder (STD) A hypothetical reference model of a decoding process used to describe the semantics of the Digital Television Standard multiplexed bit stream.

time-stamp A term that indicates the time of a specific action, such as the arrival of a byte or the presentation of a presentation unit.

TOV Threshold of visibility, defined as 2.5 data segment errors per second.

transport stream packet header The leading fields in a transport stream packet up to and including the continuity_counter field.

variable bit rate Operation where the bit rate varies with time during the decoding of a compressed bit stream.

VBV See *video buffering verifier*.

video buffering verifier (VBV) A hypothetical decoder that is conceptually connected to the output of an encoder. Its purpose is to provide a constraint on the variability of the data rate that an encoder can produce.

video sequence A video sequence is represented by a sequence header, one or more groups of pictures, and an end_of_sequence code in the data stream.

8 VSB Vestigial sideband modulation with 8 discrete amplitude levels.

16 VSB Vestigial sideband modulation with 16 discrete amplitude levels.

3.3 Symbols, Abbreviations, and Mathematical Operators

The symbols, abbreviations, and mathematical operators used to describe the Digital Television Standard are those adopted for use in describing MPEG-2 and are similar to those used in the "C" programming language. However, integer division with truncation and rounding are specifically defined. The bitwise operators are defined assuming two's-complement representation of integers. Numbering and counting loops generally begin from 0.

3.3.1 Arithmetic Operators

+	Addition.
–	Subtraction (as a binary operator) or negation (as a unary operator).
++	Increment.
- -	Decrement.
* or	Multiplication.
^	Power.
/	Integer division with truncation of the result toward 0. For example, 7/4 and –7/–4 are truncated to 1 and –7/4 and 7/–4 are truncated to –1.
//	Integer division with rounding to the nearest integer. Half-integer values are rounded away from 0 unless otherwise specified. For example 3//2 is rounded to 2, and –3//2 is rounded to –2.
DIV	Integer division with truncation of the result towards – .
%	Modulus operator. Defined only for positive numbers.
Sign( )	Sign(x) = 1 $x > 0$ = 0 $x == 0$ = –1 $x < 0$

pages 16-22 omitted

5.1.3 Overview of Video Compression

The video compression system takes in an analog or uncompressed digital video source signal and outputs a compressed digital signal that contains information that can be decoded to produce an approximate version of the original image sequence. The goal is for the reconstructed approximation to be imperceptibly different from the original for most viewers, for most images, for most of the time. In order to approach such fidelity, the algorithms are flexible, allowing for frequent adaptive changes in the algorithm depending on scene content, history of the processing, estimates of image temporal and spatial complexity and perceptibility of distortions introduced by the compression.

Figure 5.1 shows the overall flow of signals in the ATSC DTV system. Video signals presented to the system are first digitized (if not already in digital signal form) and sent to the encoder for compression; the compressed data then are transmitted over a communications channel. On being received, the possibly error-corrupted compressed signal is decompressed in the decoder, and reconstructed for display.

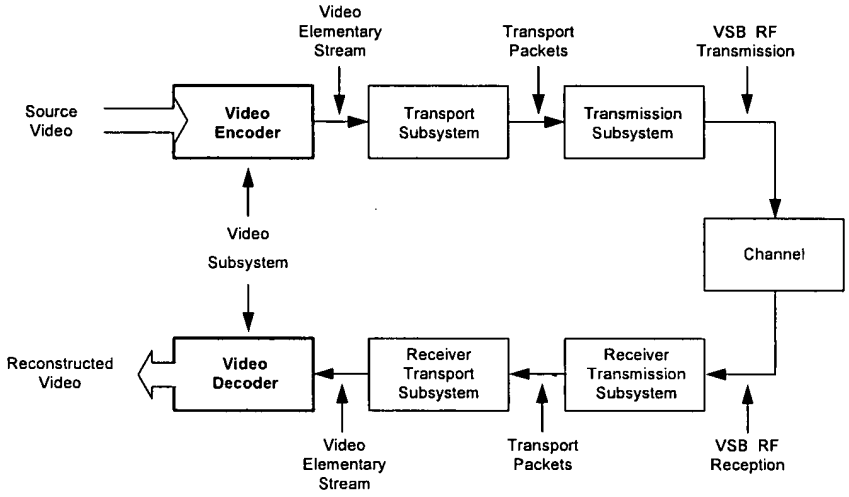

Figure 5.1 Video coding in relation to the DTV system.

5.2 Video Preprocessing

Video preprocessing converts the input signals to digital samples in the form needed for subsequent compression. Analog input signals are typically composite for standard definition signals or components consisting of luminance (Y) and chrominance (Pb and Pr) for high definition signals, are first decoded (for composite signals) then digitized as component luminance (Y) and chrominance (Cb and Cr) signals. Digital input signals, both standard definition and high definition, are typically serial digital signals carrying Y, Cb, Cr components. The input signals may undergo pre-processing for noise reduction and/or other processing algorithms that improve the efficiency of the compression encoding. Further processing is then carried out for chrominance and luminance filtering and sub-sampling (see Section 5.2.5 for more information).

5.2.1 Video Compression Formats

Table 5.1 lists the video compression formats allowed in the Digital Television Standard.

Table 5.1 Digital Television Standard Video Formats

Vertical Lines	Pixels	Aspect Ratio	Picture Rate
1080	1920	16:9	60I, 30P, 24P
720	1280	16:9	60P, 30P, 24P
480	704	16:9 and 4:3	60P, 60I, 30P, 24P
480	640	4:3	60P, 60I, 30P, 24P

In Table 5.1, "vertical lines" refers to the number of active lines in the picture. "Pixels" refers to the number of pixels during the active line. "Aspect ratio" refers to the picture aspect ratio. "Picture rate" refers to the number of frames or fields per second. In the values for picture rate, "P" refers to progressive scanning, "I" refers to interlaced scanning. Note that both 60.00 Hz and 59.94 (60x1000/1001) Hz picture rates are allowed. Dual rates are allowed also at the picture rates of 30 Hz and 24 Hz.

Receiver designers should be aware that a larger range of video formats is allowed under SCTE 43, and that consumers may expect receivers to decode and display these as well. One format likely to be frequently encountered is 720 pixels by 480 lines (encoded from ITU-R BT. 601 input signals with 720 pixels by 483 lines). See SCTE 43, Table 3.

5.2.1.1 Possible Video Inputs

While not required by the Digital Television Standard, there are certain digital television production standards, shown in Table 5.2, that define video formats that relate to compression formats specified by the Standard.

Table 5.2 Standardized Video Input Formats

Video Standard	Active Lines	Active Samples/ Line	Picture Rate
SMPTE 274M-1998	1080	1920	24P, 30P, 60I
SMPTE 296M-2001	720	1280	24P, 30P, 60P
SMPTE 293M-2003	483	720	60P
ITU-R BT. 601-5	483	720	60I

The compression formats may be derived from one or more appropriate video input formats. It may be anticipated that additional video production standards will be developed in the future that extend the number of possible input formats.

5.2.1.2 Sampling Rates

For the 1080-line format, with 1125 total lines per frame and 2200 total samples per line, the sampling frequency will be 74.25 MHz for the 30.00 frames per second (fps) frame rate. For the 720-line format, with 750 total lines per frame and 1650 total samples per line, the sampling frequency will be 74.25 MHz for the 60.00 fps frame rate. For the 480-line format using 704 pixels, with 525 total lines per frame and 858 total samples per line, the sampling frequency will be 13.5 MHz for the 59.94 Hz field rate. Note that both 59.94 fps and 60.00 fps are acceptable as frame or field rates for the system.

For both the 1080- and 720-line formats, other frame rates, specifically 23.976, 24.00, 29.97, and 30.00 fps rates are acceptable as input to the system. The sample frequency will be either 74.25 MHz (for 24.00 and 30.00 fps) or 74.25/1.001 MHz for the other rates. The number of

total samples per line is the same for either of the paired picture rates. See SMPTE 274M and SMPTE 296M.

The six frame rates noted are the only allowed frame rates for the Digital Television Standard. In this document, references to 24 fps include both 23.976 and 24.00 fps, references to 30 fps include both 29.97 and 30.00 fps, and references to 60 fps include both 59.94 and 60.00 fps.

For the 480-line format, there may be 704 or 640 pixels in the active line. The interlaced formats are based on ITU-R BT. 601-5; the progressive formats are based on SMPTE 294M. If the input is based on ITU-R BT. 601-5 or SMPTE 294M, it will have 483 or more active lines with 720 pixels in the active line. Only 480 of these active lines are encoded. The lines to be encoded should be lines 23–262 and 286–525 for 480I and lines 45–524 for 480P, as specified in SMPTE Recommended Practice RP-202, "Video Alignment for MPEG Coding." Only 704 of the 720 pixels are used for encoding; the first eight and the last eight are dropped. The 480-line, 640 pixel picture format is not related to any current video production format. It does correspond to the IBM VGA graphics format and may be used with ITU-R BT. 601-5 sources by using appropriate resampling techniques.

5.2.1.3 Colorimetry

For the purposes of the Digital Television Standard, "colorimetry" means the combination of color primaries, transfer characteristics, and matrix coefficients. Video inputs conforming to SMPTE 274M and SMPTE 296M have the same colorimetry; in this document, this will be referred to as SMPTE 274M colorimetry. Note that SMPTE 274M colorimetry is the same as ITU-R BT. 709 Part 2 colorimetry. Video inputs corresponding to ITU-R BT. 601-5 should have SMPTE 170M colorimetry.

ISO/IEC 13818-2 allows the encoder to signal the input colorimetry parameter values to the decoder. If sequence_display_extension() is not present in the bit stream, or if color_description is zero, the color primaries, transfer characteristics, and matrix coefficients are assumed to be implicitly defined by the application. Therefore, the colorimetry should always be explicitly signaled using sequence_display_extension(). If this information is not transmitted, receiver behavior cannot be predicted.

In generating bit streams, broadcasters should understand that some receivers will display 480-line formats according to SMPTE 170M colorimetry (value 0x06) and 720- and 1080-line formats according to SMPTE 274M colorimetry (value 0x01). It is believed that few receivers will display properly the other colorimetry combinations allowed by ISO/IEC 13818-2. Legacy material using SMPTE 240M colorimetry should be treated as if it used ITU-R BT. 709 Part 2 colorimetry.

5.2.2 Precision of Samples

Samples are typically obtained using analog-to-digital converter circuits with 10-bit precision. After studio processing, the various luminance and chrominance samples will typically be represented using 8 or 10 bits per sample for luminance and 8 bits per sample for each chrominance component. The limit of precision of the MPEG-2 Main Profile is 8 bits per sample for each of the luminance and chrominance components.

5.2.3 Source-Adaptive Processing

The image sequences that constitute the source signal can vary in spatial resolution (480 lines, 720 lines, or 1080 lines), in temporal resolution (60 fps, 30 fps, or 24 fps), and in scanning

pages 26-30 omitted

working in this area, MPEG has adopted an amendment to the MPEG-2 Video standard to include active area data.

Letterboxed movies can be seen on cable, satellite, and terrestrial channels today. If one observes closely, considerable variability in the size of the black bar areas can be seen. In fact, variations can be seen even over the course of one movie.

As mentioned previously, a display device may wish to mitigate the effects of uneven screen aging by substituting gray video for the black areas. It is problematic for the display to be required to actively track a varying letterbox area, and real-time tracking of variations from frame to frame would be difficult (if not impossible).

Clearly, two approaches are possible. First, include—on a frame-by-frame basis—a video parameter identifying the number of black lines (for letterbox) or number of black pixels (for pillar-box). Second, standardize on just two standard aspect ratios: 16:9 and 4:3.

5.5.3 Treatment of Active Areas Greater than 16:9

Any wide-screen source material can be coded into a 16:9-coded frame. No aspect ratio for coded frames exceeding 16:9 is standardized for cable, terrestrial broadcast, or satellite transmission in the U.S. If the aspect ratio of given content exceeds 16:9, the coded image will be letterboxed inside the 16:9 frame, as shown in Figure 5.9, where 2.35:1 material is letterboxed inside the 16:9 frame.

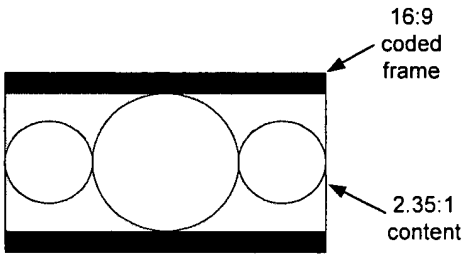

Figure 5.9 Example of active video area greater than 16:9 aspect ratio.

It can be helpful for a display to know the actual aspect ratio of the active portion of the 16:9 coded frame for a variety of reasons, including:

- Reduction in the effects of uneven screen aging. The display device controller may wish to use gray instead of black for the bars.
- The display may offer the user a "zoom" option to make better use of available display area, and knowledge of the aspect ratio can automate the selection of this display option. The zoom feature can be vertical scaling only, or a combination of horizontal and vertical where the leftmost and rightmost portions of the image are sacrificed to fill the screen area vertically.

Several standards include aspect ratio data. The MPEG-2 video syntax includes horizontal and vertical size data and aspect ratio indication of the coded image. An NTSC signal is normally thought to be intended for 4:3 display, but this is not always the case. EIA-608-B includes a "squeezed" bit, and IEC 61880 defines a method for NTSC VBI line 20. The line-20 method is currently used for playback of anamorphically coded DVDs, when the DVD player supports it and is properly set up by the user.

pages 32 and above omitted

BUYING A DIGITAL TELEVISION

Digital Television (DTV) is an entirely new technology that will ultimately replace today's analog television system. Digital signals are transmitted using computer code – ones and zeroes - which means they are less susceptible to interference and provide a higher quality picture and sound than analog.

High-definition TV (HDTV) is the best quality DTV. HDTV's sound and picture quality are many times better than today's analog TV. DTV also can be standard definition (SD) [good] or enhanced definition (ED) [better].

What you need to watch DTV:
DTV (including HDTV) is available over-the-air using a standard antenna or via digital cable or satellite. No matter how you receive your TV signal (cable, satellite or over-the-air), you will need DTV equipment to watch the DTV programming.

DTV equipment may be purchased as an all-in-one or component solution.
"Integrated" DTV sets with built-in tuners are an all-in-one solution for DTV – they include a digital tuner to receive over-the-air DTV broadcasts and a monitor to display the programming.

A "component" solution includes a DTV monitor (screen) without a DTV tuner (these monitors are sometimes labeled "HD Ready"). Monitors must be paired with a cable or satellite set-top box, or stand-alone DTV tuner.

"Digital cable ready" (or "plug-and-play") televisions are also available that can be used to receive digital cable TV without a separate set-top box. A CableCARD that can be plugged into the set is needed for certain cable programming.

Analog TVs will need additional equipment to receive over-the-air television when the DTV transition ends.
Today most people have analog televisions. All broadcast TV stations in the country have temporary use of a second, separate channel so that they can transition from analog broadcasting to digital. Legislation is currently pending to move the final phase target deadline for ending analog broadcasting to February, 2009. When analog broadcasting ends, consumers with analog sets will need to obtain a separate converter box to watch over-the-air TV. Analog sets equipped with a converter box will display the digital broadcasts, but not in full digital quality.

www.dtv.gov

Definitions

Analog TV: Today's TV system using radio frequency waves to transmit and display pictures and sound.

Digital TV (DTV): Television delivered and displayed using radio frequency waves that contain information that is digitally encoded for improved quality and efficiency.

Standard Definition TV (SDTV): Basic digital television transmission that may be displayed with fewer than 480 progressively scanned lines (480p) in 16 x 9 or 4 x 3 format. 480 interlaced (480i) is the quality of today's analog TV system. SDTV provides 150-300,000 pixels.

Enhanced Definition TV (EDTV): A Better digital television transmission than SDTV with at least 480p, in a 16 x 9 or 4 x 3 display and Dolby digital surround sound. 480p is the quality used by most DVD players. EDTV provides 300-400,000 pixels.

High-Definition Television (HDTV): The best quality digital picture, widescreen (16 x 9) display with at least 720 progressively scanned lines (**720p**) or 1080 interlaced lines (**1080i**) and Dolby digital surround sound. HDTV provides 900,000-2.1 million pixels.

HDTV Monitor (sometimes called HDTV Ready): A set that can display HDTV programming if you have a separate HDTV tuner, HD Cable Set-Top Box or HD Satellite Set-Top-Box Receiver.

HDTV Tuner (also decoder, receiver, set-top box):
A device capable of receiving and outputting HDTV signals for display. May be stand-alone or integrated in the set.

Integrated HDTV: An HDTV that has the digital tuner built into the set. It does not need a separate set-top box to receive over-the-air DTV signals.

Plug-and-Play or Digital Cable Ready: A DTV or other device for digital cable customers that plugs directly into the cable jack and does not require a separate set-top box. Plug and Play TV owners must obtain a **CableCARD** from their cable company in order to view scrambled programming services.

Interlace Scan: A way to scan vertical lines onto a TV picture by scanning all the odd lines first, then filling in the even lines (this happens instantaneously).

Progressive Scan: A way to scan vertical lines onto a TV picture by scanning all the lines consecutively (progressively).

Aspect ratio:
4 X 3: Traditional TV "aspect ratio," that is, the screen's width as compared to its height. For example, a "32 inch TV screen" would be 25 ½ inches wide and 19 inches tall.
16 X 9: "Widescreen" TV "aspect ratio" that is more like a movie screen than a traditional TV. For example, a "32 inch TV screen" would be 28 inches wide and 16 inches tall.